THE ECOLOGY OF THE UPPER WILLIAMS RIVER AND BARRINGTON TOPS DISTRICTS. I.

INTRODUCTION.

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(Plate xiv, two maps and ten Text-figures.)

[Read 27th October, 1937.]

The coastal districts of New South Wales are largely occupied by a forest formation dominated by species of the genus *Eucalyptus*. Two additional formations are present, the sub-tropical and the sub-antarctic rain-forests. These occur east of the Great Dividing Range in sheltered areas of good soil and a high rainfall. Both these formations are usually to be found in isolated areas in river and mountain valleys or on soil derived from basalt. The sub-tropical rain-forest is found chiefly in the northerly parts of the State, and the sub-antarctic rain-forest at high elevations in the centre and north, and in Victoria.

Each isolated area of rain-forest is relatively homogeneous and usually has a characteristic composition, differing slightly in this from neighbouring areas. Those furthest south are depauperated and mixed with Eucalypt forest components. As one progresses north the forests increase in richness of species, and in complexity and density.

Parts of the Eucalypt forest formation have been described in detail by Petrie (1925), Patton (1933), Petrie, Jarrett and Patton (1929), and Davis (1936).

The only ecological work on New South Wales rain-forests is that of Brough, McLuckie and Petrie (1924), who examined an area of impure sub-tropical rain-forest on basaltic soil at Mount Wilson. A comprehensive account of the distribution of rain-forests in eastern Australia and the soil on which they occur is given by Francis (1929). Apart from these nothing has been published on the New South Wales rain-forests except lists of species found in localized areas (Maiden, 1894, 1895, 1898; Chisholm, 1934, 1937).

Petrie, Jarrett and Patton (1929) described the impure sub-antarctic rain-forest of Victoria, and recently Tommerup (1934) described the sub-tropical rain-forest and Eucalypt forest formations in southern Queensland. Herbert (1935) has defined the area in Australia which should be suitable for the development of rain-forest, basing his calculations on temperature and effectiveness of precipitation. According to Herbert most of the coastal rain-forest of New South Wales occurs in the area of mild mesothermal climate, and the conditions of precipitation effectiveness favourable to the development of rain-forest are shown to be discontinuous.

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Very little planned ecological work has been attempted on tropical rain-forests. The most important in recent years is that of Davis and Richards (1933–4) and Richards (1936) on the rain-forests of British Guiana and North Borneo. Earlier investigators have paid special attention to the climatic features of the environment, and to the reaction of the individual species to these, or to the morphology of the component species, or to the general description of plant structures.

The reasons for the lack of intensive work on rain-forests are the inaccessibility of most areas, their complexity, and the difficulty of identification of the component species. The New South Wales rain-forests are, on the whole, accessible and their component species are moderately well known.

In this series of papers a description is given of an area in the Williams and Allyn River valleys (latitude 32° S., longitude 151·5° E. approx.) in which Eucalypt forests, and sub-tropical and sub-antarctic rain-forests occur. The structure and composition of these forests and the relationships of the rain-forests to the surrounding Eucalypt forest formation are discussed. Regeneration within the forest and along the margins is also described. For comparison brief accounts are given of rain-forests developed in the valleys of associated river-systems.

Except for the Barrington Tops Plateau, the area studied forms part of the Chichester State Forest Reserve. This reserve includes the upper valleys of the Paterson, Allyn, Williams, Chichester and Wangat Rivers. Part of its southern boundary is shown in Map 1. Outside this boundary the country has been extensively cleared for grazing, but inside it is relatively untouched except for some areas in the lower sub-tropical rain-forest and *Eucalyptus saligna* forest where some timber has been cut. The northern limit of the Forest Reserve is the southern escarpment of the Barrington Tops Plateau.

A small amount of grazing by cattle and horses during the summer is carried on on the Barrington Tops Plateau, but grazing is never heavy and does not seem to have caused any important change in the flora.

The Williams River rain-forest area has been found especially interesting for study because it shows the following features:

(i). The contiguity of two different rain-forest formations and their interactions with each other and with the Eucalypt forest formation.

(ii). It is further inland than any other important area of rain-forest in New South Wales, and is separated from the coastal rain-forests by a zone of low rainfall. With the exception of the Gosford and Illawarra sub-tropical rain-forests it is also the most southerly development of this formation of any considerable size. It is, therefore, in a position to yield interesting data relative to distribution and migration of rain-forest species from the north and east.

(iii). There is relatively little variation in rainfall and soil fertility within the area occupied by the rain-forests.

(iv.) Timber cutting has not yet been so severe as to destroy large tracts of the original flora. Before settlement, the Williams River rain-forest was fairly well stocked with good timber of large size. The most important economic species were: red cedar (*Cedrela australis*), rosewood (*Dysoxylum Fraseranum*), white beech (*Gmelina Leichhardtii*), and brown beech (*Litsea reticulata*). Most such valuable timber has been removed from the accessible parts, together with some sassafras (*Doryphora sassafras*), and blue gum (*Eucalyptus saligna*). The more inaccessible parts of the forest towards the head-waters of the river are, however, as yet relatively untouched.

Factors of the Environment.

Physiography.

(*a*) General.

The main dividing range, which for the most part is parallel with the coast-line, has been cut back considerably by the western tributaries of the upper Hunter River, so that here it is further west than elsewhere in New South Wales. This part of the range is also much lower than the areas to the north and south, and thus forms a gap 1,800 feet above sea-level which has been called the Cassilis Geocol. At the point where the main range swings west around the Hunter valley, a branch, the Mount Royal Range, diverges from it, trending south by south-east. This, increasing from about 2,000 feet to a maximum of about 5,000 feet, culminates in a plateau region, the Barrington Tops Plateau (Map 2). To the south the plateau has a decided margin or edge in the form of an escarpment (Plate xiv, fig. 2), and its boundary is also well defined to the west (Plate xiv, fig. 3), but in other directions the boundaries are less sharp.

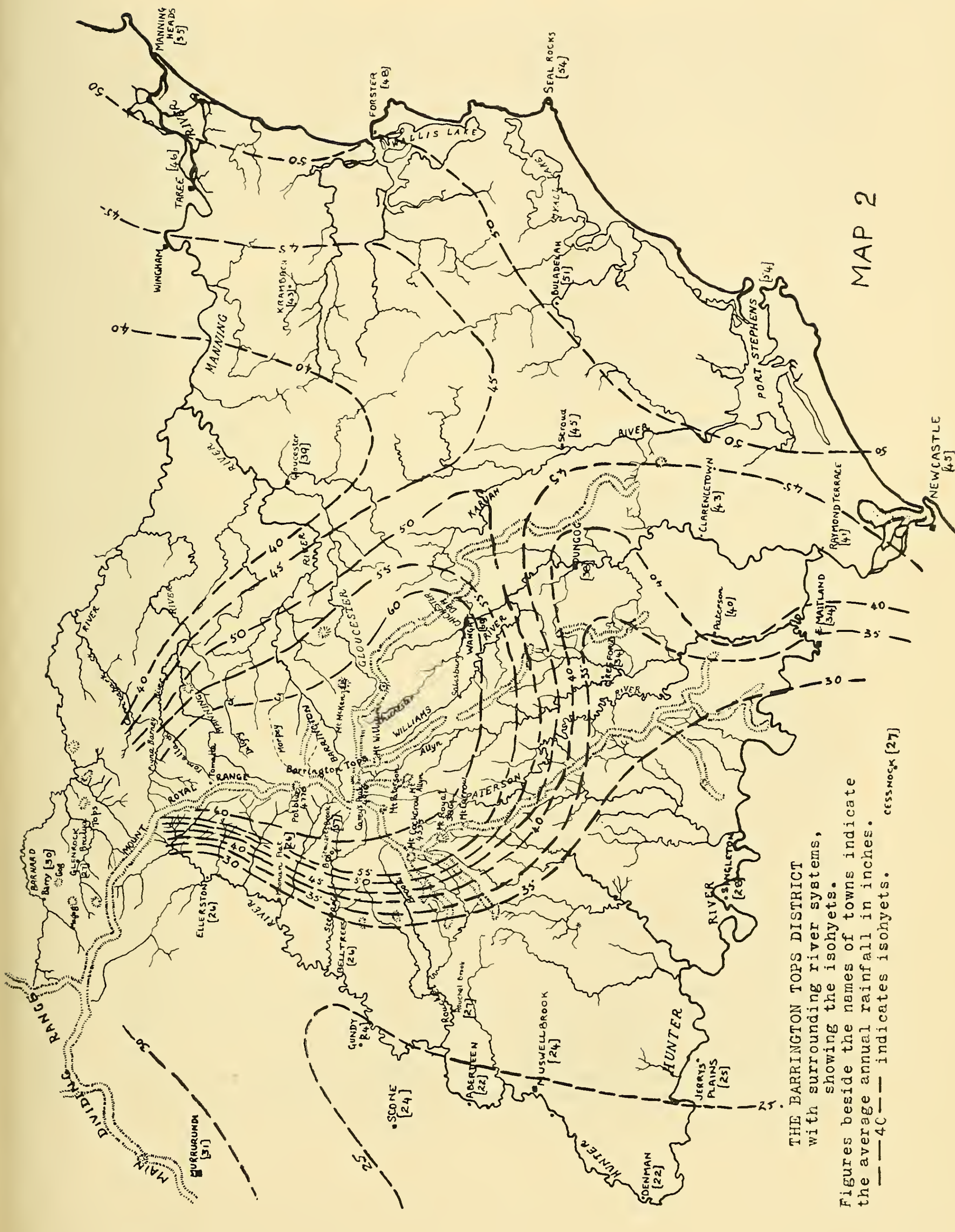
The western part of the Mt. Royal Range and the Barrington Tops separate the upper Hunter River and its tributaries from the southern tributaries of the Manning River (Map 2). From the southern escarpment of the Barrington Tops Plateau there runs a very striking series of parallel and relatively simple ridges which separate the Paterson, Allyn, Williams and Chichester Rivers, tributaries of the lower Hunter River (Plate xiv, figs. 1 and 2). To the east, ranges of decreasing size separate the head-waters of the Karuah and Gloucester Rivers.

The topography of the Barrington Tops Plateau is of a mature nature, its height above sea-level being about 4,500–5,000 feet. It extends about 6–10 miles in an east-west direction by about 15 miles in a north-south direction. It is part of a late Tertiary peneplain which once extended over the whole of eastern Australia, which has been raised and almost completely eroded. This small residual area is, however, partly undissected and must show in places much the same topography as it did before the uplift. On the plateau towards its southern extremity the landscape is characterized by undulating country with gently rounded hills rising to a height of 200 feet above the general level, and considerable swamps which occupy the low ground between (Plate xiv, fig. 7). These swamps form the head-waters of the Barrington River, which flows in a general easterly direction. After leaving the plateau the Barrington River plunges into a deep, narrow chasm which is gradually cutting back and draining the swamps. To the south the plateau ends abruptly in the escarpment overlooking the heads of the Williams, Allyn and Paterson Rivers (Plate xiv, fig. 4). The northern part of the plateau is drained by the Pigna Barney, Tomalla, Gummi (Upper Manning), Dilgry and Morpey Rivers, whose courses show a sequence similar to that of the Barrington River. The only streams of any size which drain the plateau to the west are the tributaries on the eastern bank of the upper Hunter River, the Rouchel, Moonan and Stewart's Brooks. In their upper parts these are entrenched to a considerable extent.

(*b*). Detailed description of the area studied.

The valleys of the Paterson, Allyn, Williams and Chichester Rivers, which arise from the southern escarpment of the Barrington Tops Plateau, are separated by ridges which are at first flat topped and fairly wide (Plate xiv, fig. 2). These diminish in height from 5,000 feet to 1,600 feet at Salisbury in the Williams River valley and Eccleston in the Allyn River valley, becoming progressively narrower as the valley floors increase in width and become flatter (Plate xiv, fig. 4). The


MAP 1
The UPPER WILLIAMS and ALLYN RIVER VALLEYS showing the dissected nature of the dividing ridges.
—, approximate boundary of basalt rock (after G.D.Osborne)
----, boundary of State Forest.
CHICHESTER
RANGE
WILLIAMS
RIVER
RANGE
WILLIAMS
ALLYN
RIVER
ALLYN
RANGE
Mt ALLYN
Shell Brook
EDGE OF PLATEAU
4100'



THE BARRINGTON TOPS DISTRICT
with surrounding river systems,
showing the isohyets.
Figures beside the names of towns indicate
the average annual rainfall in inches.
——40—— indicates isohyets.

rivers have few affluents of any size, but the dividing ridges are dissected by numerous small creeks and therefore have a complex system of spurs (Map 1). The lateral slopes of the ridges are very steep, 15°–45° or more, being steepest near the plateau (Plate xiv, figs. 1 and 2). In the upper parts of the Allyn and Williams valleys occasional vertical rock faces occur. These are not numerous, as the nature of the rock causes it to weather into steep slopes. The lower parts of the main spurs and the lower spurs are less steep, and the small creeks which drain them are entrenched to a depth of 100–200 feet, so that their beds and sides are more sheltered than the crests of the spurs. The upper courses of the creeks which drain the flat parts of the ranges near the Barrington Tops Plateau have a tendency to be swampy. On leaving the tops of the ridges they become very steep and the creeks are deeply entrenched.

The valley of the Williams River is 2½ miles wide from ridge to ridge at the southern limit of the rain-forest (X in Map 1), and narrows gradually towards its source. It is enclosed by ranges averaging about 700–1,000 feet higher than the river bed, trending south-south-east and north-north-west. The valley floor and lower slopes are therefore shaded from the sun and sheltered from the winds to a greater degree than the upper slopes and crests of the ridges. Towards the head-waters of the river the country is very rough and its detailed topography is unmapped. The whole course of the river is marked by cataracts and falls as far south as Salisbury, so that the upper part is not much more entrenched in the mountains near its source than it is at 1,000 feet.

The Allyn-Williams divide (the Williams Range) is uniformly high and protects the Williams valley from westerly winds. The Allyn River valley is rather wider than the Williams (about 3 miles) and the westerly mountain range is less uniformly high than the Williams Range, so that the lower part of the valley is less sheltered than that of the Williams at a corresponding point south.

The head-waters of the Allyn River are entrenched about 3,000 feet below the southern escarpment of the Barrington Tops Plateau; this upper part of the valley is therefore as shaded and sheltered as any part of the Williams valley (Plate xiv, figs. 1 and 4).

The Chichester-Williams divide (the Chichester Range) is more broken than the Williams Range, and the Chichester valley is therefore slightly less sheltered and shaded than the Williams and upper Allyn valleys. The valley is wider than that of the Williams, the slopes less steep, and the actual floor of the valley less flat. The head-waters are very sheltered.

The different degrees of shelter met with in the three valleys have a marked influence on the vegetation.

Geology.

The writers are indebted to Dr. G. D. Osborne, of the Department of Geology, University of Sydney, for the following information.

A large area of the Barrington Tops Plateau is occupied by quartz-monzonite and associated plutonic types in the form of a batholith. The remainder is composed of flows of basalt and sheets and sills of dolerite. This basalt also forms the tops of the ranges diverging from the plateau. The base of the basalt flows varies in height, but in the vicinity of the Williams River stands at about 1,800–2,000 feet above sea-level (Map 1).

Below the basalt, occupying the valley floors and sides of the ridges, are Carboniferous sediments, chiefly impure limestone and mudstone.

Dr. Osborne concludes that after the Carboniferous sediments were laid down they were subjected to folding, and then eroded in the late Tertiary to a peneplain having as its surface Carboniferous sediments and some dioritic and monzonitic masses intrusive into the Carboniferous rocks and standing above them. Tertiary flows of basalt were poured on this, and later plugs and sills broke across the flows. The plutonic rocks outcropping on the plateau are evidently part of an old residual around which the flows of basalt were poured out.

The great difference in the elevation of the plateau and the lowlands to the south has been attributed by some geologists to step faulting, throwing to the south, but no evidence has been found by Dr. Osborne in support of this view. He considers that the condition is due mainly to erosion.

Soil.

The Carboniferous sediments outcropping in the Williams and Allyn River valleys and ridges weather to form a light-coloured clay. Along the valley floor the soil may be of considerable depth and greyish to blackish-brown in colour with humus and material derived from the basalt rocks on the ridge tops. The usual soil of the valley sides and spurs is a yellowish clay which appears to be of considerable depth, while rock outcrops are rare.

The basalt capping the ridges weathers to a chocolate-brown or dark grey, loamy clay. On the flat ridge tops and on the plateau, rock outcrops are very rare and the soil appears to be deep. On the steep upper sides of the ridges approaching the plateau, outcrops of partially decomposed basalt and occasional rock faces can be seen. The soil is deep in pockets, and does not appear to be washed off to any great extent because of the continuous vegetation cover.

On the dioritic part of the plateau occasional rounded boulders occur as in typical granite country; for the most part the soil is a deep, slightly sandy loam.

No detailed study of the soils derived from the various rock formations has been made. From field observations it appeared improbable that the nature of the soil or parent rock was a limiting or deciding factor in the distribution of the plant formations or the species within the area, except perhaps in rare instances. On the other hand, certain aspects of the soil, such as the humus content, were very obviously governed by the plant cover. It was therefore considered necessary at this stage to make only a few comparative tests on a number of representative samples from different localities and from the different plant formations, as illustrations of the edaphic conditions of the area. The soil samples were all taken from about 5 cm. below the surface of the soil.

Table 1 summarizes the results of analyses of the humus content, water-retaining capacity, pH, and some mechanical features of the soils tested. The soil textures were determined according to the method of Hardy (1928). The humus content was estimated by the hydrogen-peroxide method (Prescott and Piper, 1928). The pH was determined by the quinhydrone electrode method. The water-retaining capacity was obtained by estimating the percentage loss of weight from a saturated soil sample dried at 25° C.

No. 1 soil sample is a chocolate-coloured fine silt taken from a typical part of the valley floor covered by sub-tropical rain-forest.—No. 2 is a greyish-brown fine silt taken close to a small creek, and covered by sub-tropical rain-forest.—No. 3 is a yellowish fine silt taken from the lower slopes of a spur covered by sub-tropical rain-forest.—No. 4 is a greyish-brown fine silt taken near a creek, supporting *Tristania conferta* and some rain-forest trees.—No. 5 is a greyish-brown heavy loam from an area occupied by the margin of the sub-tropical rain-forest.—

No. 6 is a greyish-brown fine silt taken from a ridge near No. 7, but from an advancing margin of the sub-tropical rain-forest.—No. 7 is a yellowish-brown heavy loam taken from the top of a ridge, supporting Eucalypt forest.—No. 8 is a greyish-brown fine silt taken high up on the slopes of the Williams-Allyn ridge and supporting a Eucalypt forest association.—No. 9 is a dark chocolate clay from the top of an exposed ridge, about 3,500 feet altitude, supporting Eucalypt forest.—No. 10 is a dark chocolate-coloured clay supporting sub-antarctic rain-forest, at an altitude of about 4,000 feet.

No. 1 is river alluvium, No. 2 is derived from limestone, Nos. 3, 4, 5, 6, 7, 8 from mudstone, and Nos. 9 and 10 from basalt.

The soils vary in texture from a heavy loam to clay, and have a fairly high water-retaining capacity. The marked difference between the figures for the loss on ignition and the humus content of most of the soils is accounted for by the presence of a considerable amount of finely-divided organic matter which cannot be separated from the soil, but which is as yet only partially decomposed. In some instances the soils were of such a peaty nature that on ignition they burned with a pronounced flame, e.g., sample No. 10.

TABLE 1.

Soil Number.	Soil Type.	Sand. %.	Water-retaining Capacity. %.	Loss at 100° C. %.	Loss on Ignition. %.	Humus Content. %.	pH.
1	Fine silt	0	44	4·1	15·8	11·2	5·75
2	Fine silt	7·5	34	2·5	10·7	6·7	4·45
3	Fine silt	5·5	38	5·2	17·1	7·8	5·3
4	Fine silt	13·0	35	2·5	10·2	6·7	4·9
5	Heavy loam	8·8	26	2·9	8·3	4·2	5·4
6	Fine silt	0·2	42	4·5	18·6	10·9	4·9
7	Heavy loam	12·7	30	3·0	9·8	5·2	5·0
8	Fine silt	11·4	35	4·7	11·8	7·0	5·2
9	Clay	0·7	39	12·1	24·0	10·9	5·65
10	Clay	0	45	14·2	44·9	20·5	4·5

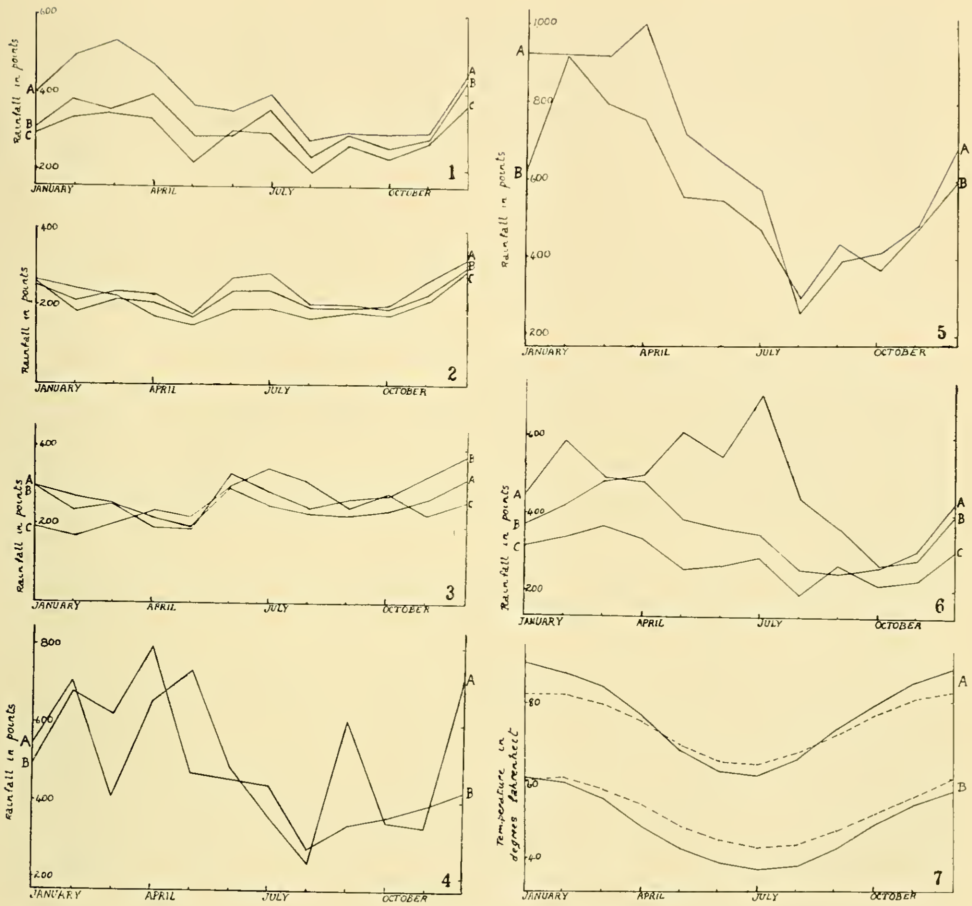
The surface of the soil in the sub-tropical rain-forest is covered by a layer of partly-decayed leaves and twigs to a depth of 1–3 cm. or more, depending on the position. An even greater amount is present in the sub-antarctic rain-forest, where, owing to the lower temperature, decay is probably slower. A considerable accumulation of dry and partly-decayed leaves and twigs is also present on the surface of the ground in the Eucalypt forest.

The soil of the rain-forests is continuously damp, the more so at the higher levels. The soil of the Eucalypt forests is frequently dry. The upper Eucalypt forests are moister than the lower.

Climate.

(*a*). Rainfall and Winds.

No rainfall data are available for the Barrington Tops Plateau, or for the upper parts of the river valleys draining it. The stations nearest to the area under investigation at which rain records have been taken are Wangat (6,017 points p.a., average for 6 years only) to the south-east of the plateau on the upper Chichester River, and Stewart's Brook (5,704 points p.a.) to the west.



Text-figures 1-6 show the average monthly rainfall recorded for stations in the vicinity of the Barrington Tops.

Text-fig. 1.—Stations east and south-east of the plateau in the dry belt. A, Stroud (average of 46 years); B, Dungog (average of 37 years); C, Gresford (average of 38 years).

Text-fig. 2.—Stations in the Upper Hunter Valley west of the plateau. A, Moonan Flat; B, Rouchel Brook; C, Scone (average of 59 years).

Text-fig. 3.—Stations north-west of the plateau, near the Mount Royal Range or Main Dividing Range. A, Murrurundi (average of 64 years); B, Nundle; C, Barry.

Text-fig. 4.—Stations nearest to the plateau. A, Wangat (average of 6 years); B, Stewart's Brook.

Text-fig. 5.—Stations on highland areas to the north of the plateau. A, Dorrigo (average of 19 years); B, Comboyne (average of 30 years).

Text-fig. 6.—Stations on or near the coast, east of the plateau. A, Taree (average of 52 years); B, Port Stephens (average of 44 years); C, Maitland (average of 68 years).

Text-fig. 7.—Average mean maximum (A) and average mean minimum (B) temperatures for stations nearest to the Barrington Tops Plateau at which records are kept. ———— Scone (height above sea-level, 682 feet); — — — Taree (height above sea-level, 31 feet).

The rainfall is chiefly due to the north-east monsoons which operate during the late summer and autumn. A certain amount of rain is also received from southerly rain-bearing winds which blow chiefly during the winter and, approaching the plateau along the parallel valleys of the Allyn, Williams and other rivers, precipitate their moisture on the southern margin of the plateau and dividing ranges. Though no data are available, it seems probable that the greatest amount of rain is received by the south-eastern and north-eastern margins of the plateau at about 4,500–5,000 feet.

An attempt has been made to plot from records available the distribution of rainfall in the districts surrounding the plateau (Map 2). It can be seen that the annual rainfall decreases from the coast inland, rising again as the highlands are approached, so that there is a zone including the lower Williams and Paterson River valleys which is comparatively dry. Wangat, with an altitude of about 1,000 feet, receives the highest rainfall recorded, viz., 6,017 points. The rainfall is probably high along the whole of the Mt. Royal Range, but owing to the direction of the rain-bearing winds the greatest rainfall must be received by the south-easterly and southerly margins of the plateau. By analogy with the similarly-placed highland masses of the Comboyne and Dorrigo plateaus to the north, and from the appearance of the vegetation, it seems likely that the plateau itself must receive considerably more than this, probably more than 8,000 points p.a.

The amount of rain received diminishes very rapidly to the west of the plateau region. In the region of the Cassilis Geocol the Dividing Range does not appear to be an effective barrier to rain-bearing winds and consequently this region receives a relatively small amount of rain. The dryness of this area is, no doubt, in part due to the sheltering action of the Barrington Tops Plateau.

The distribution of rainfall throughout the year in the area surrounding the plateau is shown in Text-figures 1–6. It can be seen that a well-defined dry season is not experienced in any of the localities; a fairly even amount of rain is received throughout the year. There is a slight tendency for a maximum in the autumn in the Dungog, Clarencetown and coastal districts (Text-figs. 1 and 6), but this is not shown in the upper Hunter River district (Text-figs. 2 and 3). Stewart's Brook appears to receive its greatest rainfall in the late summer and autumn, but at Wangat no well-defined maximum occurs (Text-fig. 4). This is not in agreement with the records from Dorrigo and Comboyne (Text-fig. 5), which show a well-marked maximum in the autumn, and a minimum in the late winter and early spring. It is possible that a similar distribution of rainfall may occur on the Barrington Tops Plateau itself.

Throughout the summer and autumn mists are common at 4,000 feet altitude and above. These keep the upper forest permanently very wet, and encourage the growth of epiphytic lichens and mosses. The eastern parts of the plateau (2,500 feet and above) are within the sphere of influence of the sea breeze, which often causes the precipitation of light showers in the very early morning.

The only desiccating wind in the region under discussion is the westerly, which blows chiefly in the autumn, winter and early spring.

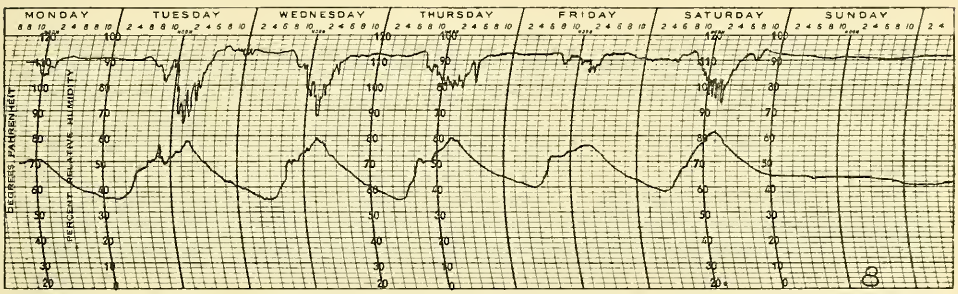
(*b*). Temperature and Humidity.

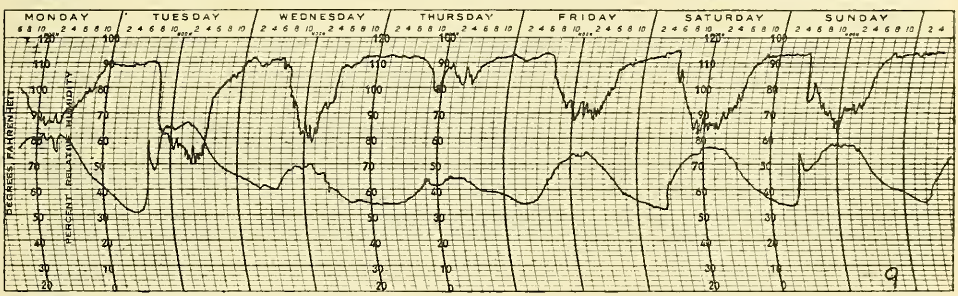
No continuous temperature data are available for the area investigated. Text-figure 7 shows the mean maximum and minimum temperatures for Scone and Taree, the nearest places to the area for which records are available.

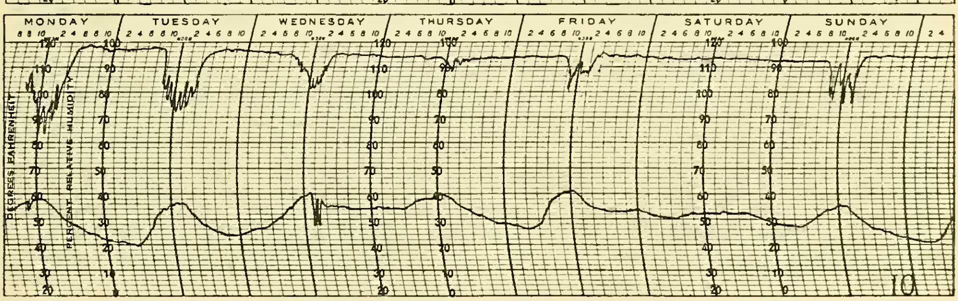
Within the sub-tropical rain-forest the temperature does not vary as much as it does in the Eucalypt forest; high temperatures are uncommon. This is due to the insulating effect of the very dense canopy. The thickness of the canopy means that there is practically no wind in the rain-forest, and hence the evaporation rate is very low and the humidity is high. This is especially noticeable as the small drop of temperature consequent on the setting of the sun behind the ridges results in a heavy dew within the rain-forest causing the trunks of the *Eucalyptus saligna* trees to become wet to a height of 30–40 feet.

Since the Eucalypt forest is relatively open the evaporation rate is much higher than in the rain-forest, and the humidity is lower.

Some isolated observations on temperature and humidity have been made in the lower rain-forest and adjacent cleared areas in the Williams River valley.







Text-figures 8–10 are Thermohygrograph records. The upper line indicates humidity, the lower line temperature.

Text-fig. 8.—Record in the lower sub-tropical rain-forest, 22nd to 28th January, 1935.

Text-fig. 9.—Record in a clearing near the sub-tropical rain-forest, 10th to 17th January, 1935.

Text-fig. 10.—Record in the lower sub-tropical rain-forest, June, 1935.

Some of these are shown in Text-figures 8–10, and illustrate the effect on the humidity of the rain-forest canopy. These were recorded by an Edney Thermo-hygrograph during summer and winter months. It was not possible to have records taken simultaneously in the rain-forest and in the cleared area, but the records shown in Text-figures 8 and 9 represent consecutive weeks of similar weather in summer. It can be seen that the daily variations are much more extreme in the cleared area. For comparison, Text-figure 10 shows a typical record for humidity and temperature for a week in June (winter) in the rain forest. It is evident from the records taken that the humidity is more uniformly high in the winter than in the summer.

No records were taken of variation of humidity from ground level to the top of the canopy. It has been found elsewhere (e.g., Davis and Richards, 1933) that in rain-forests the humidity falls off rapidly from the ground to the level of the canopy.

Frosts occur occasionally during the winter at ground level in cleared areas below the rain-forest, at about 1,000 feet altitude, but the forest cover prevents their formation in uncleared areas below about 2,000 feet. Above this altitude frost forms at ground level within the forest, the actual height at which it occurs being to some extent dependent on the degree of shelter from the west and the type of cover.

During the winter months, June to August, some falls of snow are customary on the plateau and ridges down to 4,000 feet, rarely to 3,000 feet on exposed places. The snow does not lie long on the ground, especially at the lower levels. On the plateau it is exceptional for it to remain for more than a week. It does not lie as long on swamp as on forest and grassland country.

The climate of the plateau approximates to the microthermic type similar to that responsible for the beech forests of Western Tasmania.

(*c*). Sunlight.

Crests of the spurs and the upper parts of slopes exposed directly to the west receive maximum sunlight, and high temperatures are probably experienced there; but they also experience maximum evaporation and consequently lowest temperature. The valley floor and sheltered gullies on northerly slopes probably experience least extremes of temperature.

Direct sunlight leaves the upper Williams River valley at about 2.30 p.m. during the winter months, and at about 4.30 p.m. during the summer months, and correspondingly earlier on the sheltered slopes. (In Sydney the sun rises at 6.58 a.m. and sets at 4.54 p.m. on the shortest day, 21st June, and rises at 4.41 a.m. and sets at 7.06 p.m. on the longest day, 21st December.) Some of the entrenched creeks on the northern slopes must receive only a few hours direct sunlight per day.

In the Eucalypt forest a considerable amount of sunlight reaches the ground level, as the canopy is thin. In the rain-forest, especially the sub-tropical rain-forest, only small flecks of sunlight reach the ground and the general lighting is very diffuse.

Structure of the Plant Formations.

Throughout the area studied the plant cover, of whatever kind, is continuous. Very little exposed rock surface occurs, except on the very steep upper slopes of the range near the plateau, where the basalt outcrops in the form of angular boulders, which support a rich flora of lichens and mosses. Elsewhere the soil is deep and rich and supports a complex flora of trees, shrubs and herbs.

There are, in the area, three distinct types of formation: The Eucalypt forest, the sub-antarctic rain-forest and the sub-tropical rain-forest as defined below.

Eucalypt forest formation.—Canopy continuous or nearly so, rather thin; trees 50–180 feet high according to locality; shrubs scanty to numerous, with herbs and grasses forming a continuous ground cover. This formation extends over the whole coast and adjacent highlands of New South Wales, *Eucalyptus* being the dominant genus.

Sub-tropical rain-forest formation.—Canopy continuous, very dense, moderately deep; trees very numerous, 60–120 feet high; shrubs and young trees fairly numerous; ground flora mostly ferns with few herbs, scanty except in light breaks; epiphytic ferns and Angiosperms and lianes numerous, giving this forest a characteristic appearance; trees belonging to a large number of different genera.

The same general type of formation is found throughout the moist areas of the tropics and extends to sub-tropical countries. The sub-tropical rain-forest of eastern Australia has closest affinities with that of the Indo-Malayan Islands. Its composition is less rich and dense, however, and it has few actual species and genera in common with it.

As understood in this paper, the term sub-tropical rain-forest is synonymous with the term brush as used in New South Wales, but not in Queensland, and with the terms scrub and jungle as used in Queensland.

Sub-antarctic rain-forest formation.—Canopy continuous, fairly dense, very deep; trees 90–150 feet high; one species often dominant; tree-ferns and ferns very numerous in damp places, otherwise the ground flora rather scanty; lianes and epiphytic ferns and Angiosperms very few. It is part of the formation extending into Tasmania, parts of New Zealand and South America. The number of species present is smaller than in the sub-tropical rain-forest.

General Description of the Vegetation of the Area.

The upper sheltered parts of the valleys of the rivers draining the south-east, east, and north-east of the Barrington Tops Plateau are occupied by the sub-tropical rain-forest formation. Its extent in any particular area depends on the degree of shelter from the west, and on the rainfall. In no case in this district does the formation extend below about 1,000 feet altitude, as below this level not only are the valleys wider and more sunny, but also, being further from the plateau, the total rainfall is less. The sub-tropical rain-forest occupies the floors and sheltered sides of the valleys and the beds of creeks which drain the spurs. Towards the lower margin it does not occupy the whole valley floor, but is present only on the banks of the river. In favourable places it extends upwards to a height of 3,000 feet. At this height it gives place gradually to the sub-antarctic rain-forest which extends to 5,000 feet along creeks and sheltered slopes, having its maximum development at 4,000–4,500 feet.

The amount and character of the rain-forest in the different valley systems depends on their aspect and on the rainfall. Its greatest development appears to be in the valleys of the upper Paterson, Allyn and Williams Rivers.

The lower valleys of Stewart's, Moonan and Rouchel Brooks, which are exposed to the west and receive a lower rainfall, do not support a true rain-forest. Their upper courses, which are slightly entrenched in the plateau and are therefore sheltered, appear to support a few patches of sub-antarctic rain-forest.

The upper parts of the Barrington, Manning, Tomalla and Curriecabark Rivers, where they are entrenched in or near the plateau, support both sub-tropical and sub-antarctic rain-forest.

The lower valley of the Manning, into which these streams flow, is wide and relatively open (Plate xiv, fig. 6), but a considerable amount of rain-forest is present as far down as Coneac (but only at a level of about 400 feet above the river bed) on sheltered slopes and in the beds of creeks where the soil is moist (Plate xiv, figs. 5 and 6). Plate xiv, figure 6, shows the development of rain-forest on the north-east-facing slope of the valley and its absence from the west-facing slope). This extends in discontinuous patches to Gloucester, linking up there with the rain-forests of the Kramback region described by Maiden (1895).

The valley of the upper Barnard River, which drains the northern part of the Barrington Tops Plateau and the Mount Royal Range, appears to be much drier and does not support a rain-forest vegetation.

The extent of the rain-forest in the upper Karuah and Gloucester River valleys has not been determined.

The valleys below the rain-forest, the crests and upper slopes of ridges, the plateau region, and upper valleys of the western and north-western rivers except actually on the plateau, are occupied by Eucalypt forest. The character of the Eucalypt forest and nature of the undergrowth alter with increasing altitude. The trees reach their maximum height in the valleys, and are smallest on the Barrington Tops Plateau.

The lower lying ground of the plateau is occupied by extensive swamps, and between the swamps and the Eucalypt forest is a grassland community of varying width, from which trees and large shrubs are absent (Plate xiv, fig. 7). The swamps are gradually being drained by the cutting-back action of the Barrington River, along part of whose course the change of vegetation from swamp to grassland and from grassland to forest can be traced.

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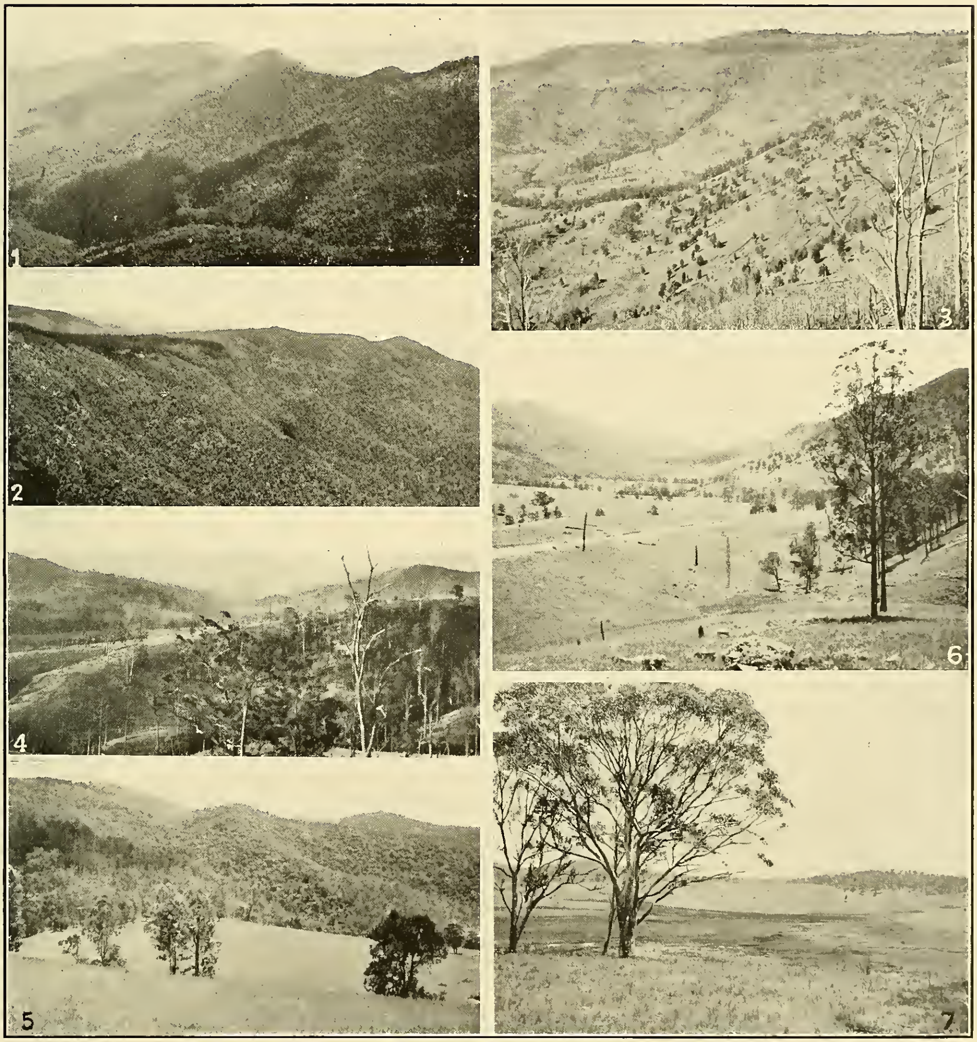

Upper Williams River and Barrington Tops Districts.